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TTS-35 Delta Field Trials Dryden District

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ABSTRACT

The TTS-35 Delta was operated on a variety of sites (totalling 219 ha) during field trials in the Ear Falls, Ontario area. The machine was successful in preparing medium and heavily slashed, clay and sand sites. On clay sites, the net exposure averaged 50 percent with an average of 1689 plantable spots per hectare. On sandy sites, the net exposure averaged 62 percent with an average of 2660 plantable spots per hectare. The TTS-35 Delta proved its ability to prepare sites effectively for planting and seeding.

I. INTRODUCTION

Over the past years, as technology has advanced, several site-specific pieces of equipment have evolved. As we are now able to site prepare more sites, owing to advances in management techniques, a need has developed for a more versatile machine to cut down the expense of moves. The TTS-35 Delta is a machine that has the capability to adapt to varying topography, slash, soil types, and soil depths.

The purpose of this field trial was to operate the TTS-35 Delta under severe slash conditions and then to evaluate its performance on primarily tractor barrel-and-chain sites.

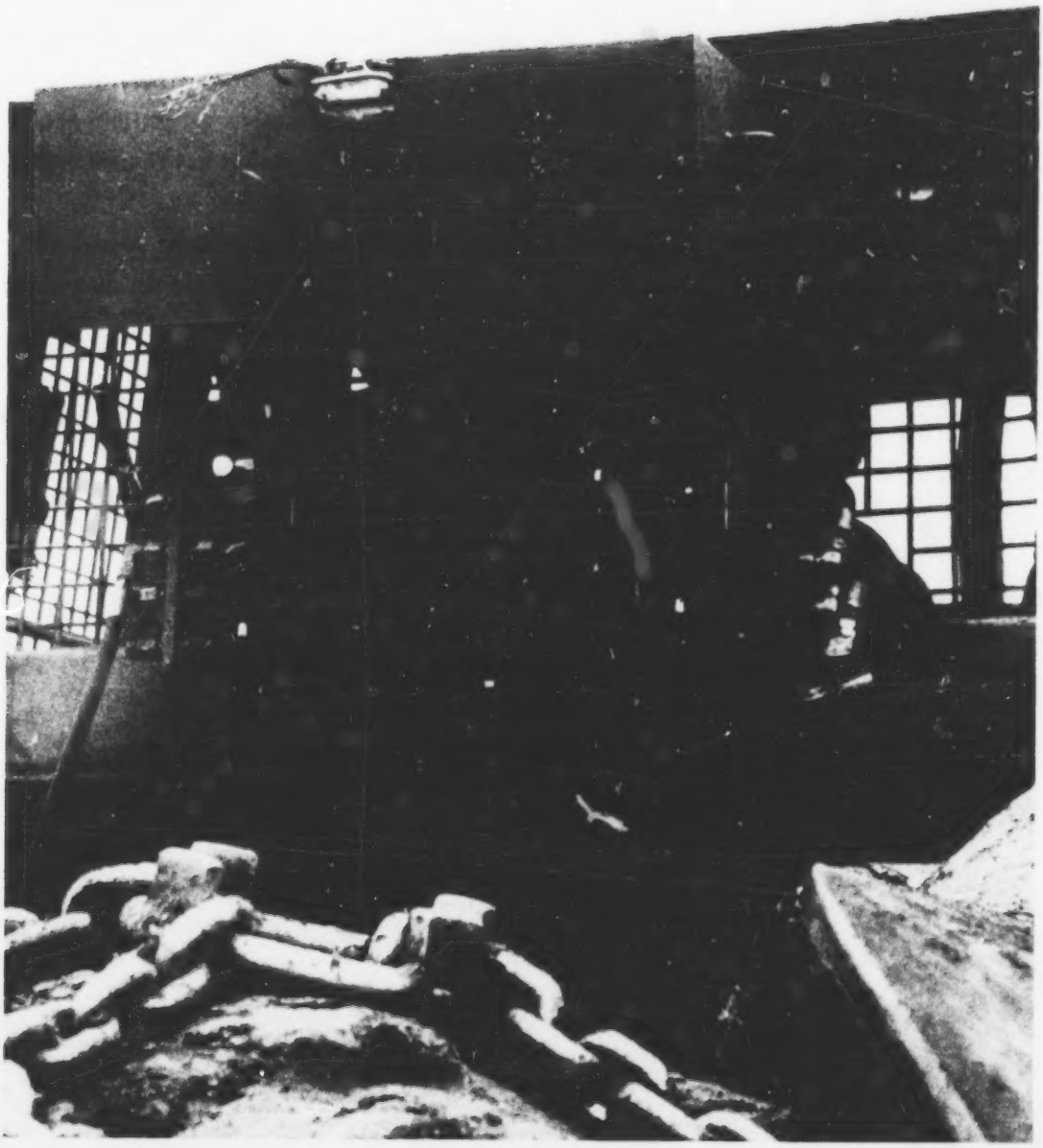

Figure 1. Electrically controlled hydraulic valve arrangement. (Note both the easy access to the hydraulic valves and the protective cover above the valves.)

II. DESCRIPTION OF THE TTS-35 DELTA

The TTS-35 Delta is a hydraulically controlled two-row disc scarifier. Its operating controls are initiated electrically through a manual control panel. The controls open hydraulic valves which direct the fluid flow to or away from the trencher arms. The internal hydraulic pressure is monitored and adjusted by a manual pressure control valve. It uses its variable down pressure settings to adjust to varying site conditions. The arms, which mechanically operate independently of each other, will react to any obstruction greater than the pressure control valve setting. The main hydraulic valve will redirect the fluid to bypass the down pressure cylinders allowing the discs to pass the obstruction (Figure 1). The variable setting is controlled by the prime-mover operator and can be adjusted while the machine is operating or stopped. The automatic overdrive system redirects the flow to the arms as soon as the obstruction is passed. In this manner the machine can maintain a consistent speed over an area with only down pressure fluctuating on a pass. Having the control panel in the cab of the skidder also allows the operator to lift the machine at any time and thus cut down on stuck and turn around times.

The major advantages to using this machine are the manually operated direct drive and automatic safety override systems. Other advantages include its narrow travelling position and light weight. These allow the machine to travel on roads quickly and without causing damage. This will maximize total productive land treatability on small, heavily slashed or heavy in residual sites.

The discs on the TTS-35 Delta are the same as on the conventional TTS-35[1] disc-trencher; hence they are easily attainable. The arms pivot to adjust the angle of the disc in 22-degree settings internally with three 6-degree external fine settings. The disc angle and down pressure gauge must be adjusted together in order to achieve optimal furrows with minimal wear and tear. The scarifier can be mounted on any skidder or tractor which is capable of pulling a minimum capacity of 100 kilonewtons and of driving a 200-litre hydraulic system.

For the purposes of this field trial the TTS-35 Delta (see Table 1) is mounted on a Timber Jack 550 which had a 200-litre hydraulic drive system added to the prime mover to operate the scarifier.

[1]Discs may be bought in varying teeth lengths to accommodate different sites.

Table 1: TTS-35 Delta Specifications

Supplier: Hakmet Equipment
Weight: 3t (includes hydraulics)
Length: 2.4 m
Width: 2 m - 2

Down pressure range: 0 to 3000 PSI
Minimum lifting pressure: 2000 PSI
Pilot pressure range: 0 to 30 bars (closed centre)
Disc diameter: 1.2 m

Prime mover:
- Minimum hydraulic fluid flow — 60 L/m
- Minimum hydraulic fluid capacity — 200 L
- Minimum prime mover requirement — 100 kN

Figure 2. Operating position.
(Note the discs positioned on maximum vertical angle.)

Figure 3. Travelling position.
(Note the narrow width.)

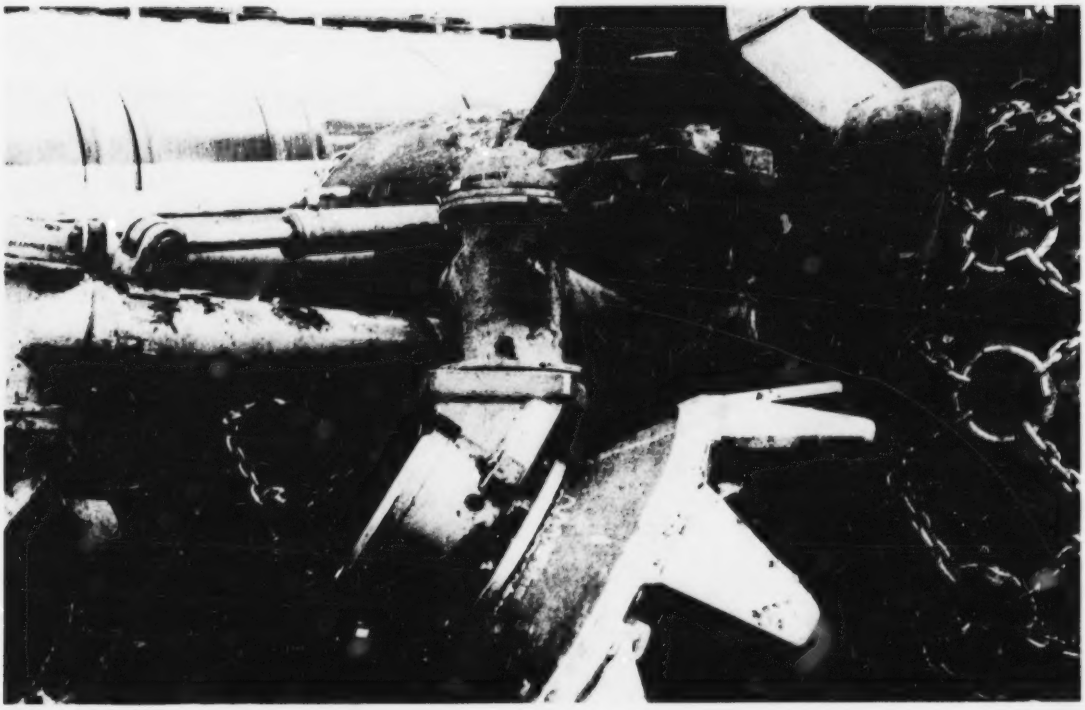

Figure 4. Mechanical arrangement.
(Note the disc angle adjustment arm.)

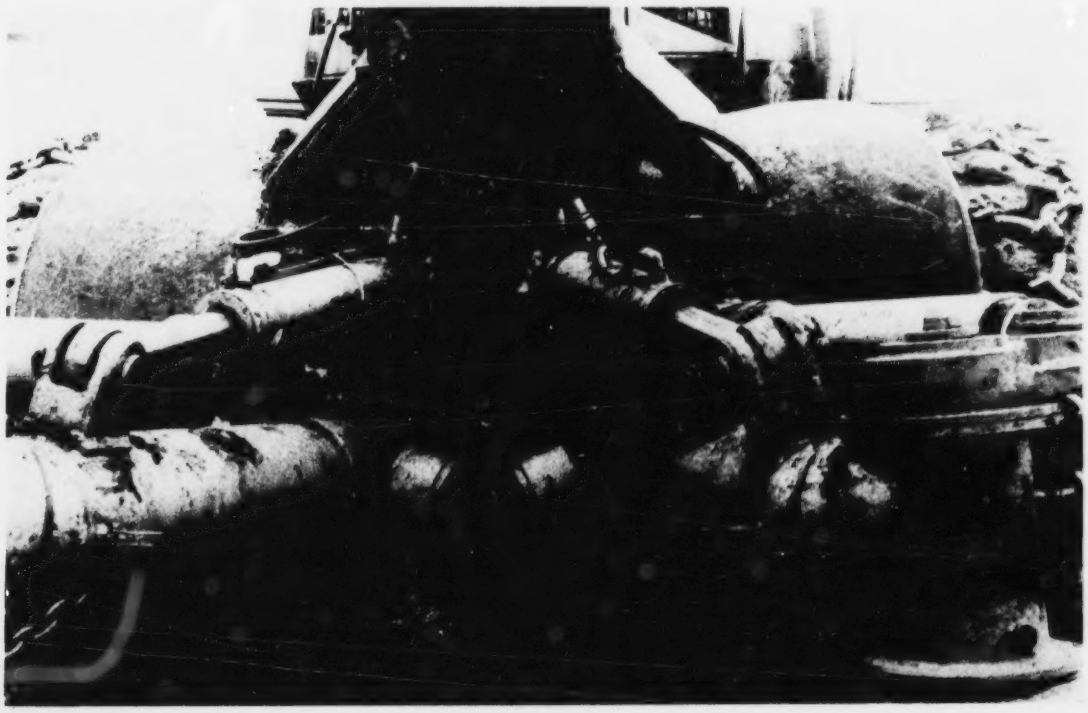

Figure 5. Down pressure hydraulic hoses and cylinders.
(Note the individual hinges that allow free arm movement.)

III. METHOD OF EVALUATION

The TTS-35 Delta was evaluated on several sites in the southern section of the Red Lake District (Ear Falls area) by the Dryden District timber staff. A total of 219 hectares were scarified.

Allowing for variability in the site interpretation, we have prepared a visual "before and after" presentation of each type of site along with a detailed description and site summary evaluation.[1]

Owing to the longevity of the project (August 18, 1984 to November 11, 1984), the SIP plot evaluation varied according to manpower availability. Therefore a re-evaluation by the same staff was conducted on all sites during the latter stages of the operation to ensure uniformity in the sampling. The sampling intensity averaged 0.17 percent.

The procedure used to evaluate the quality of the site preparation is summarized as follows:

a) Initially all sites were stratified by cut year, slash component, soil type, and ground cover.
b) Circular 50 m^2 plots were located throughout the area systematically by site type.
c) Plot centres were marked in the field with circumference of plot located by marking transecting furrows.
d) Measurements were made of each furrow noting total length, length exposed, average width of exposure, and plantable spots.
e) Each plot was summarized by specific site classification to produce gross exposure[2] totals, net exposure[3] totals, and optimal plantable spots.[4]

1 "Before and after" site photographs are not necessarily of the exact same location but a location within the type.
2 Gross exposure equals length of soil exposed in the furrows versus total surface area.
3 Net exposure equals length of soil exposed in the furrows versus total furrow length.
4 Plantable spots are the number of microsites along the furrows that could, using conventional methods, adequately sustain a planted tree.

Figure 6. Site type 1 before site preparation.

Figure 7. Site type 1 after site preparation.

IV. FIELD TRIAL SITES AND QUALITY EVALUATIONS

Table 2: Description of Type 1 Site and Equipment Specifics

Description

Soil type: silty clay
Soil depth: 120+ cm
Duff depth: 12 cm
Drainage: moderate to good
Slash: 30 cm in depth — Pj, Sp tops — Po logs
Stoniness: none
Topography: flat to gently rolling
Area: 21 ha
Year of cut: 1983/84
Residuals: scattered Po, Bf
Ground vegetation: moderate Po, hazel, and grass
Climate conditions: very dry
Previous stand: overmature Pj, Sw, Po; advanced growth Bf

Equipment Specifics

Trencher setting: middle disc angle — 2800 PSI down pressure
— 2100 PSI down pressure
Average production: 1.07 ha/h
Machine availability: 28%*

* Note the poor availability of the machinery due to lack of proper maintenance of equipment and spare parts in the initial trial.

Table 3: Summary of Quality of Type 1 SIP

Plot Number	Net Exposure Percentage	Gross Exposure Percentage	Plantable Spots Per Hectare
1	48	6	1600
2	27	2	800
3	22	2	1200
4	39	5	1800
5	33	4	1200
Average	34	4	1320*

* The quality achieved in this site does not represent the true capability of the TTS-35 Delta. Field staff were, in this initial site, unfamiliar with the machine.

Table 4: Description of Type 2 Site and Equipment Specifics

Description

Soil type: silty clay
Soil depth: 120+ cm
Duff depth: 12 cm
Drainage: moderate to good
Slash: 30 cm in depth -- Pj, Sp tops — Po logs
Stoniness: none
Topography: flat to gently rolling
Area: 37 ha
Year of cut: 1983/84
Residuals: scattered Po, Bf
Ground vegetation: moderate Po, hazel, and grass
Climate conditions: very dry
Previous stand: overmature Pj, Sw, Po; advanced growth Bf

Equipment Specifics

Trencher setting: middle disc angle — 2100 PSI down pressure
Average production: 1.07 ha/h
Machine availability: 27%*

* Note the poor availability of the machinery due to lack of available spare parts.

Figure 8. Site type 2 before site preparation.

Figure 9. Site type 2 after site preparation.

Table 5: Summary of Quality of Type 2 SIP

Plot Number	Net Exposure Percentage	Gross Exposure Percentage	Plantable Spots Per Hectare
1	41	3	1400
2	80	7	2600
3	32	3	1200
4	61	5	1400
5	59	4	2000
6	60	6	2000
7	54	4	1400
8	83	8	2600
Average	59	5	1825

Figure 10. Site type 3 before site preparation.

Figure 11. Site type 3 after site preparation.

Table 6: Description of Type 3 Site and Equipment Specifics

Description

Soil type: fine sand
Soil depth: 120+ cm
Duff depth: 6 cm
Drainage: rapid
Slash: 60 cm in depth — Pj tops and branches
Stoniness: scattered 4 to 6 cm
Topography: gently rolling
Area: 15 ha
Year of cut: 1984/85
Residuals: Sb, Bf advanced growth
Ground vegetation: light to feather moss
Climate conditions: 15 cm of snow
Previous stand: Pj8, Sb2; 80 a*

Equipment Specifics

Trencher setting: maximum vertical disc angle — 2200 PSI down pressure
Average production: 1.66 ha/h
Machine availability: 80%

* Year (annum).

Table 7: Summary of Quality of Type 3 SIP

Plot Number	Net Exposure Percentage	Gross Exposure Percentage	Plantable Spots Per Hectare
1	78	8	2800
2	68	8	2800
3	86	10	2800
Average	77	9	2800

Table 8: Description of Type 4 Site and Equipment Specifics

Description

Soil type: fine sand
Soil depth: 8 to 10 cm
Duff depth: 5 cm
Drainage: rapid
Slash: 40 cm — Pj, Sb tops and branches
Stoniness: none
Rock outcrops: soil over bedrock
Topography: moderate slopes
Area: 12 ha
Year of cut: 1984/85
Residuals: scattered Po, Bf
Ground vegetation: light to feather moss
Climate conditions: 15 cm of snow
Previous stand: Sb6, Pj2, Po1, Bf1

Equipment Specifics

Trencher setting: maximum vertical disc angle — 2200 PSI down pressure
Average production: 1.53 ha/h
Machine availability: 80%

Figure 12. Site type 4 before site preparation.

Figure 13. Site type 4 after site preparation.

Table 9: Summary of Quality of Type 4 SIP

Plot Number	Net Exposure Percentage	Gross Exposure Percentage	Plantable Spots Per Hectare
1	68	7	2400
2	84	9	2800
3	32	3	2000
Average	61	6	2400

Figure 14. Site type 5 before site preparation.

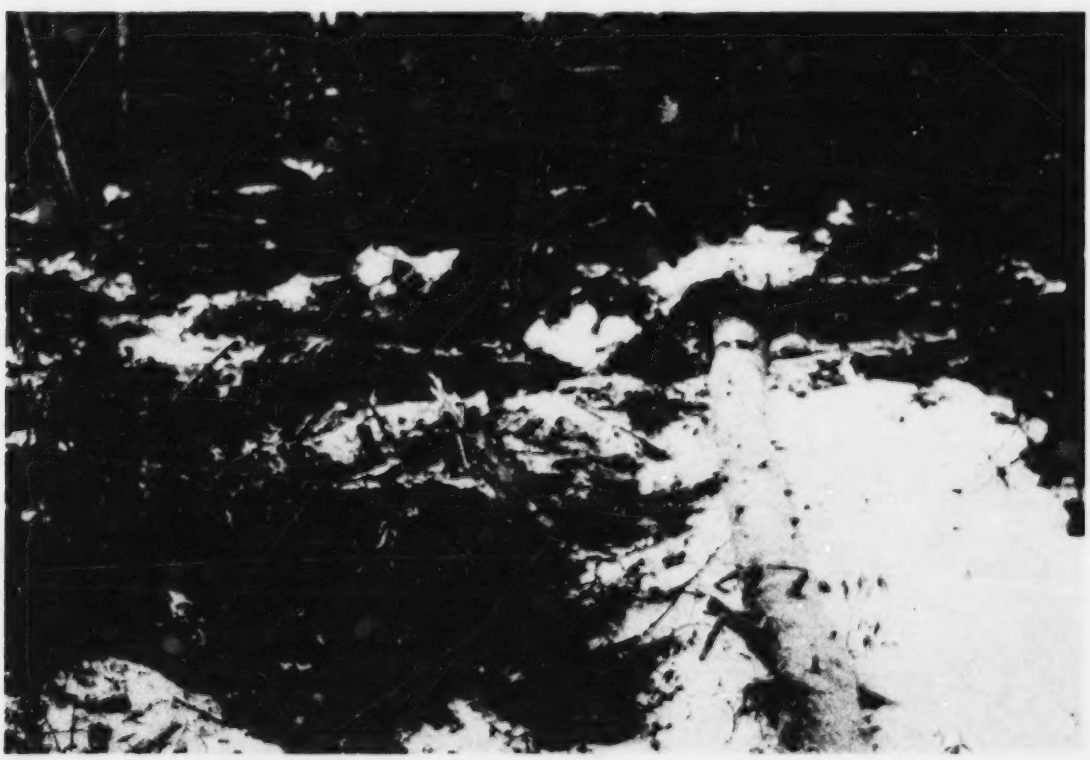

Figure 15. Site type 5 after site preparation.

Table 10: Description of Type 5 Site and Equipment Specifics

Description

Soil type: medium sand
Soil depth: 120+ cm
Duff depth: 14 cm
Drainage: good to rapid
Slash: 60 cm in depth — Pj, Sb, Bf tops and branches
Stoniness: frequent stones 6 to 8 cm
Topography: flat to gently rolling
Area: 48 ha
Year of cut: 1984/85
Residuals: scattered Po and overmature Pj
Ground vegetation: feather moss and sphagnum
Climate conditions: 20 cm of snow; wet
Previous stand: overmature Pj, Sb; advanced growth Bf

Equipment Specifics

Trencher setting: maximum vertical disc angle — 2500 PSI down pressure
Average production: 1.28 ha/h
Machine availability: 73%

Table 11: Summary of Quality of Type 5 SIP

Plot Number	Net Exposure Percentage	Gross Exposure Percentage	Plantable Spots Per Hectare
1	100	10	3200
2	82	12	3200
3	84	7	1800
4	88	14	3600
5	52	5	2600
6	60	5	2200
Average	73	9	2767

Table 12: Description of Type 6 Site and Equipment Specifics

Description

Soil type: silty clay
Soil depth: 120+ cm
Duff depth: 13 cm
Drainage: moderate to good
Slash: 30 cm in depth -- Pj, Sp, Bf tops — Po logs
Stoniness: none
Topography: gently rolling
Area: 13 ha
Year of cut: 1983/84
Residuals: heavy Bf advanced growth; scattered Po
Ground vegetation: moderate grass; Po suckering
Climate conditions: 8 cm of snow; 3 cm frost
Previous stand: Sb4, Pj3, Po2, Bf1; 120 a

Equipment Specifics

Trencher setting: maximum vertical disc angle — 2200 PSI down pressure
Average production: 1.17 ha/h
Machine availability: 100%

Figure 16. Site type 6 before site preparation.

Figure 17. Site type 6 after site preparation.

Table 13: Summary of Quality of Type 6 SIP

Plot Number	Net Exposure Percentage	Gross Exposure Percentage	Plantable Spots Per Hectare
1	60	6	2200
2	77	9	2600
3	43	5	1200
4	34	3	1600
5	69	7	1800
6	9	1	2000
Average	49	5	1900

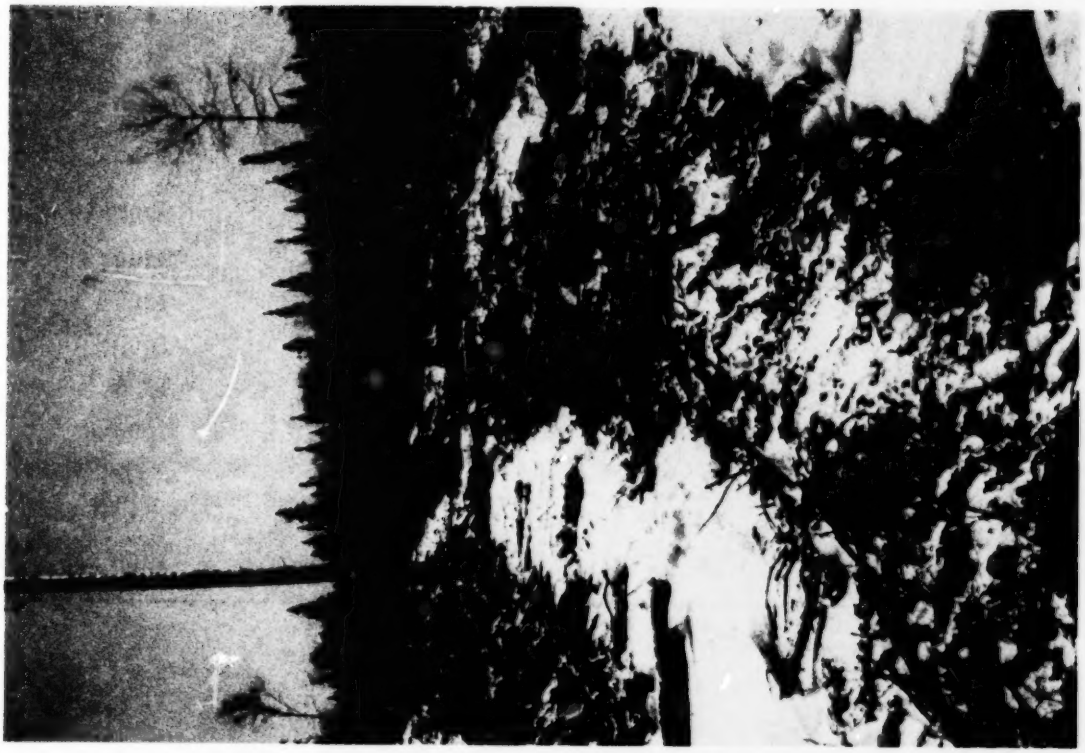

Figure 18. Site type 7 after site preparation.

Figure 19. A furrow close-up in site type 7.

Table 14: Description of Type 7 Site and Equipment Specifics

Description

Soil type: medium sand
Soil depth: 120+ cm
Duff depth: 6 cm
Drainage: good
Slash: 25 cm — compressed Pj, Sb tops and branches
Stoniness: scattered stones 6 to 8 cm
Topography: flat to gentle slopes
Area: 73 ha
Year of cut: 1983/84
Residuals: scattered Po, Bw
Ground vegetation: light feather moss
Climate conditions: wet
Previous stand: Pj8, Sb1, Po1; 80 a

Equipment Specifics

Trencher setting: maximum vertical disc angle -- 2200 PSI down pressure
Average production: 1.17 ha/h
Machine availability: 20%*

* Note the low availability of machinery due to water contamination of the hydraulic system. The machine was down for 10 days. The contamination was due to outside influences.

Table 15: Summary of Quality of Type 7 SIP

Plot Number	Net Exposure Percentage	Gross Exposure Percentage	Plantable Spots Per Hectare
1	43	4	2200
2	44	4	1800
3	70	6	2400
4	61	5	2600
5	68	9	3000
6	14	1	600
7	100	14	3000
8	46	3	3200
9	27	1	1000
10	46	4	3000
11	84	9	3600
12	31	2	3000
13	24	2	2200
14	46	4	2600
15	60	6	3200
16	72	7	3400
17	37	4	2400
18	57	7	3200
19	16	1	2500
20	48	3	2200
21	69	9	3200
22	66	7	2800
23	60	5	2800
Average	52	5.1	2604

Table 16: Site Preparation Sumary in All Types of Sites

Site Type Number	Soil Type	Hectares Per Hour Produced	Number of Hectares	Net Exposure Percentage	Gross Exposure Percentage	Plantable Spots Per Hectare
1	clay	1.07	21	34	4	1320
2	clay	1.07	37	59	5	1825
3	sand	1.66	15	77	9	2800
4	sand	1.53	12	61	6	2400
5	sand	1.28	48	73	9	2767
6	clay	1.17	13	49	5	1900
7	sand	1.17	73	52	5.1	2604
Clay		1.09	71	50	4.7	1689
Sand		1.29	148	62	6.8	2660
All		1.28	219	58	6.1	2345

The following data suggests the kind of results other equipment operated on these sites would obtain. This data was compiled from assessments of previous projects on similar sites as well as through discussions with staff experienced in the operation of this type of equipment in the Northwestern Region.

Type of Equipment	Soil Type	Net Exposure Percentage	Gross Exposure Percentage	Plantable Spots Per Hectare
Tractors Barrels and Chains				
	Clay	55	4	1950
	Sand	60	6	2350
Bracke Cultivator				
	Clay	23	3	1200
	Sand	34	4	1400
TTS-35 Disc Trencher				
	Clay	42	3	1500
	Sand	50	5	1900

The TTS-35 Delta was operated using a skidder that was contracted through a seasonal Regional tender. The production cost was based on a rate of $104.12 per hour, with a standby rate of $50.00 per hour, and moving costs of $5.00 per mile. The following table summarizes the overall costs based on these rates.

Table 17: TTS-35 Delta Field Trial Cost Summary

Machine production cost: 171 h x $104.12/h	$17 804.52
Standby cost: 71 h x $50/h	$ 3 550.00*
Moving cost: float, crane, truck	$ 3 080.00
Supervisory cost: salaries, accommodation, vehicles, meals	$11 237.94+
Repair cost:	$ 3 537.65
Total cost:	$39 210.11
Total area treated:	219 ha
Cost/ha:	$179.04

* This cost reflects the normal standby cost of regular operation. It does not include additional standby time that results from waiting for parts from the manufacturer or for time spent in the shop decontaminating the hydraulic system.

+ The supervisory cost does not represent that of a normal operation. This is due to the length of the project, the fact that only one machine was used, and that additional staff was required for a project of this nature. This piece of equipment can be operated at a cost comparable to a light drag unit under regular production conditions (approximately $135 to $150/ha).

V. DISCUSSION

From the site descriptions and quality assessment tables you can see the outcome of the field trials of the TTS-35 Delta. On clay sites, the machine was tested using a variety of disc angles and pressure settings. During the trials it was determined that the narrow vertical disc angle with a pressure setting of 2100 PSI achieved the best results, because alignment was good and the maximum plantable spots were produced. The type 1 site results proved that maximum down pressure settings are not the answer to clay site exposure and alignment. The resistance created by clay soils with large diameter slash caused the hydraulics to bypass continually, thus creating an erratic furrow. With the down pressure reduced, the disc created a more consistent furrow and maximized its surface ground influence.

On sandy-soil sites, the TTS-35 Delta achieved maximum performance at a production rate far above any SIP equipment normally associated with these sites. These sites were obstructed by fresh heavy slash, moderate stones, compacted heavy slash, shallow soil on bedrock, and moderately deep duff. In each instance the Delta was able to achieve an acceptable seeding microsite and an excellent planting microsite. On sandy soils the pressure and disc angle settings will fluctuate due to variations in both slash and the desired surface exposure width.

The maneuverability of the Delta enables it to maximize plantable spots on all of these sites with no losses due to turnarounds or small awkward areas that would normally be bypassed (Figures 20 and 21). The TTS-35 Delta also has the capability to maneuver under residual trees and achieve an adequate alignment and microsite for tree planting.

The field trials also demonstrated that climatic conditions which would normally restrict a piece of SIP equipment did not restrict the Delta in the same manner. It worked under very wet conditions as well as in moderately deep snow. Although the upper frost layers on some sites did impede actual penetration it allowed for excellent alignment of the slash and duff for planting.

The Delta can operate on slopes angled at less than 35 percent travelling parallel to topography or perpendicular to the topography. With the direct pressure applied to the discs, regular spacing can be achieved when working along hillsides and pressure can be released further up slopes.

Figure 20. Aerial view of SIP pattern of site type 3 (1:6336).

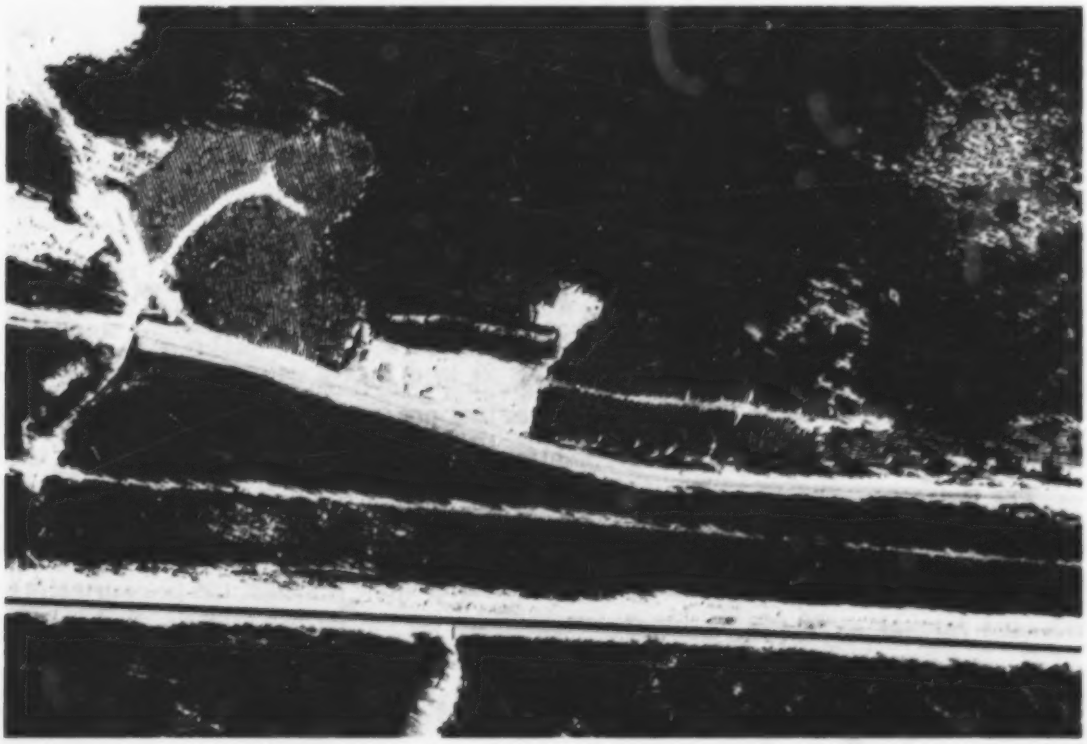

Figure 21. Aerial view of SIP pattern of site type 4 (1:6336).

The TTS-35 Delta should not be used on shallow bedrock sites with extreme topography and heavy boulder sites. These types of sites were not included in the field trials because our main objective was to test deep, heavily slashed sites. In order to maintain its cost effectiveness, it is important that the TTS-35 Delta's drive and mechanical systems be properly maintained.[1]

[1]It can be noted that during the field trials the machine encountered no mechanical problems and minimal wear on the disc teeth.

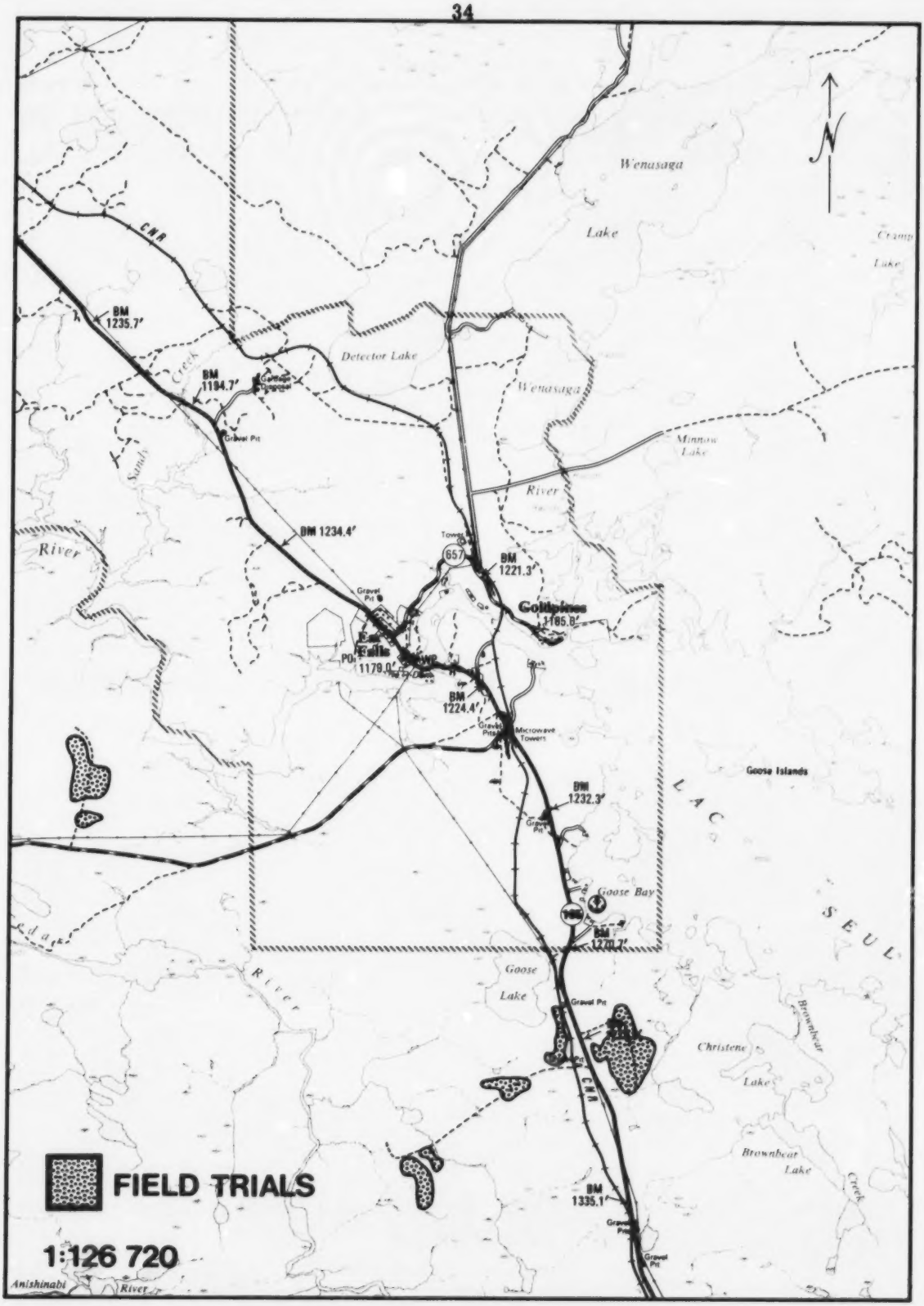

Figure 22. TTS-Delta field trial study areas.

VI. SUMMARY

The TTS-35 Delta field trials have shown that this piece of equipment can achieve an acceptable microsite for planting or seeding through its versatility, adjustable pressure controls, adjustable disc angles for varying widths of the furrows, and production speed. With proper maintenance, the TTS-35 Delta can operate effectively on heavy and light drag sites. Total cost-efficient, productive site treatability will increase with its usage.